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University of the State of New York Bulletin

Entered as second-class matter August 2, 1913, at the Post Office at Albany, N. Y., under the act of August 24, 1912

Published fortnightly

No. 573 ALBANY, N. Y. AUGUST 15, 1914

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 172

GEOLOGY OF THE ATTICA-DEPEW QUADRANGLES

BY

D. D. LUTHER

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SIR: I have the honor to submit herewith a manuscript report, with maps, on the *Geology of the Attica and Depew Quadrangles,* and to recommend the publication of this report as a bulletin of the State Museum.

Very respectfully
JOHN M. CLARKE
Director

STATE OF NEW YORK
EDUCATION DEPARTMENT
COMMISSIONER'S ROOM

Approved for publication this the 17th day of March 1913

Commissioner of Education

University of the State of New York Bulletin

Entered as second-class matter August 2, 1913, at the Post Office at Albany, N. Y., under the act of August 12, 1912

Published fortnightly

No. 573 ALBANY, N. Y. AUGUST 15, 1914

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 172

GEOLOGY OF THE ATTICA AND DEPEW QUADRANGLES

BY D. D. LUTHER

The area embraced within these quadrangles lies between the lines of 42° 45′ and 43° north latitude, and 78° 15′ and 78° 45′ west longitude and contains 455 square miles.

It is situated just where the sloping front of the great Allegany plateau begins to bend from a generally east and west line to a direction nearly southwest and parallel to the southern shore of Lake Erie.

The point of lowest altitude is in the northwest corner of the Depew quadrangle where it is 585 feet above sea level, or 338 feet above Lake Ontario and 12 feet higher than Lake Erie, while the crest of the ridge west of Varysburg reaches, on the southern boundary line of the Attica quadrangle, the height of 1780 feet, showing a difference in elevation of 1195 feet.

The rock strata of this region have an average southward dip or declination estimated to be about 33 feet a mile, or 577 feet on a north and south line across the quadrangles. Adding this thickness which is lost from the difference in elevation, the total thickness of the rock section or surface rocks shown on the maps is approximately 1772 feet.

The basal strata of this rock section to the thickness of about 100 feet belong to the Ontaric or Siluric system, and lie at the foot and to the north of the rocky declivity known as the Helderberg escarpment that extends from Albany county to the Niagara river, and crosses the Depew quadrangle near its northern boundary. The Siluric strata and their contact with the overlying basal formation of the Devonic system are finely exposed in several quarries along the front of the escarpment.

The rocks exposed in the upper part of the escarpment and the surface rocks south of it on these quadrangles belong to the

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Devonic system, all the subdivisions comprising this system in western New York being found within the area covered by the map, though the highest, the Chemung sandstones and shales, is represented by only a fraction of its thickness and over a small area.

The drift sheet or soil mantle on these areas is usually quite thin and rock outcrops are frequent except in the flat region in the northern part of the Attica quadrangle where it is much thicker and rock exposures very rare.

The Mesodevonic Marcellus and lower Hamilton beds are quite well displayed on the Depew quadrangle in the vicinity of Lancaster, along Cayuga creek and other small streams.

The gorges and gullies through which the Tonawanda, Ellicott, Cayuga and Cazenovia creeks and their numerous branches flow, show the stratigraphic details of the upper Hamilton, the Genesee and Portage beds in a manner and to an extent perhaps nowhere else found so conveniently accessible for examination and the collection of their finely preserved and abundant fossils.

The geologic formations of which the surface rocks of these quadrangles are composed and which are represented by the various colors on the map, consist of the following, in descending order:

ERA OR SYSTEM	PERIOD OR GROUP	STAGE OR AGE
Devonic	Chautauquan	Chemung sandstones and shales
		Wiscoy shale
		Nunda sandstone
		Gardeau flags and shales
		Hatch shales and flags
	Senecan	Rhinestreet black shale
		Cashaqua shale
		Middlesex black shale
		West River shale
		Genundewa limestone
		Genesee black shale
		Pyrite in Tully horizon
	Erian	Moscow shale
		Tichenor limestone
		Ludlowville shale
		Skaneateles shale
		Cardiff shale
		Stafford limestone
		Marcellus black shale
	Ulsterian	Onondaga limestone
	Oriskanian	Oriskany sandstone horizon
Siluric	Cayugan	Cobleskill limestone
		Bertie waterlime
		Camillus shale

DESCRIPTION OF FORMATIONS IN ASCENDING ORDER FROM NORTH TO SOUTH

SILURIC

CAMILLUS SHALE

The lowest in the series of rock formations shown on the map is the Camillus member of the Cayugan group, 250 to 300 feet thick, composed mainly of soft, light gray marlytes or gypseous shales with frequent thin layers of hard dolomite or magnesian limestone.

The great deposit of rock salt that underlies all southern-central and western New York is at or near the bottom of this formation and the gypsum beds of equal commercial importance, so extensively quarried in Onondaga county and westward to Genesee county, are found in the upper part. It is said that the first discovery of gypsum in the United States was made in 1792 in these beds at Camillus, Onondaga county, when the principal gypsum layer and a large part of the formation were abundantly exposed. The name of the formation is derived from this locality.

The Camillus beds are generally barren of fossils though one or more of the thin dolomites in the upper part contain at some localities the crustacean Leperditia scalaris? Jones, and one or two other obscure forms.

No exposures of this formation occur on these quadrangles but the gypsum is mined at Oakfield and Alabama, and the upper part of the formation outcrops in the banks of Tonawanda creek below Indian Falls, on the quadrangles next north of these.

BERTIE WATERLIME

In the upper part of the Camillus beds there is an alternation of shales and limestones in which the shales lose much of their gypsum and the limestones become more compact and heavier and also, by the increased proportion of magnesia carbonate, highly dolomitic. These passage beds are succeeded by about 50 feet of waterlime, dark colored when fresh but weathering to a light gray, in layers from a few inches to 3 or 4 feet thick, separated by thin seams of black carbonaceous matter. The rock in some of the layers is quite compact and the lines of deposition are barely discernible, while other layers have a laminated structure or, in small proportion to the entire mass, are more or less shaly.

The proportion of calcareous and argillaceous matter varies considerably in different layers, the composition of some of them being such as to make true hydraulic limestone or natural cement rock. A bed of this character at the top of the formation and about 6 feet thick has been quarried extensively at Buffalo, Williamsville and Akron for the production of natural cement, and other layers were formerly utilized for this purpose in the central part of the State.

This formation receives its name from its favorable exposure in the township of Bertie, Ontario. It may be seen to excellent advantage at the falls of Ellicott creek in the village of Williamsville and there are frequent small exposures of the upper beds all along the lower part of the escarpment to Clarence and the large quarry two and one-half miles farther east.

Fossils are rare in the Bertie limestone here except the ostracod, Leperditia scalaris Jones, and the small brachiopod Whitfieldella laevis (Whitfield): these two occurring in considerable numbers in several thin layers and occasionally in the more compact and thicker layers. The stratum of cement rock at the top of the formation contains the remains of a peculiarly interesting arachnid or eurypterid fauna, which has recently been fully discussed and illustrated by Clarke and Ruedemann (N. Y. State Mus. Mem. 14, 1912). The wealth of this formation in these fossils has made it widely known and of great interest to paleontologists.

COBLESKILL WATERLIME

West of the Genesee river the Bertie waterline is succeeded by a few feet, not more than 6 to 8 on the Depew quadrangle, or dark subcrystalline dolomitic limestone in uneven layers, usually not more than a few inches thick, separated by thin seams of black carbonaceous matter. After exposure this rock sometimes has a brecciated appearance and is usually more or less porous owing to the removal by dissolution of crystals of calcite and of a small coral, Cyathophyllum hydraulicum Simpson, which occurs quite abundantly here and in the Buffalo quadrangle, but is very rare or absent from the Cobleskill in the central part of the State. The rock resembles the Bertie in being very dark when freshly quarried but weathering to a light gray or buff color. It is known to quarrymen as the "bull head" or "pumpkin head," and is of considerable economic value, being used largely in Buffalo for foundation walls and similar purposes.

Beside the coral mentioned the following fossils occur in the Cobleskill waterlimes in western New York:

Nematophyton crassum *Penhallow*
Favosites sp.
Orthothetes interstriatus (*Hall*)
Spirifer eriensis *Grabau*
Whitfieldella sulcata (*Vanuxem*)
W. nucleolata *Hall, var.*
W. *cf.* laevis (*Vanuxem*)
Rhynchonella *sp.*
Loxonema?
Pleurotomaria
Trochoceras gebhardi (*Hall*)

The Cobleskill waterlime is well exposed at Williamsville in the old quarries; in the village of Clarence, and at the larger quarry two and one half miles east of Clarence on the DeWitt quadrangle, and in the Buffalo cement quarry at Buffalo, at Akron, Fallkirk, Indian Falls and Morganville, North LeRoy, East Victor and Union Springs. It received its name on account of its fine exposure at Cobleskill in Schoharie county, and it may be seen in many other localities in eastern New York.

The Cobleskill waterlime is the highest formation belonging to the Siluric system in the rock section of New York west of Seneca lake, the Rondout waterlime and the Manlius limestone that succeed the Cobleskill in the central and eastern part of the State thinning out and disappearing east of that point.

In the large cement quarries at Buffalo and at nearly all exposures where the surface or cross sections of the contact with the succeeding formation can be observed, there are evidences of considerable erosion, the Paleodevonic strata resting more or less unconformably upon the Cobleskill.

DEVONIC

ORISKANY SANDSTONE HORIZON

Four Devonic formations, the Coeymans limestone, New Scotland beds, Becraft limestone and Port Ewen limestone, constituting the Helderbergian group in the eastern New York counties are absent in the western, the Oriskany sandstone being the lowest of the Devonic subdivisions known here.

This rock in its typical condition is composed of coarse white or pinkish quartz sand, loosely cemented by calcareous matter. It is not a continuous stratum on the line of its outcrops in central and western New York, but appears in cross sections of broad

lentils the largest of which are east of Cayuga lake and attain a thickness of 20 to 30 feet, and sometimes are quite fossiliferous.

There are exposures of thin lentils at Phelps, Honeoye Falls and Morganville and a vertical crevice in the Cobleskill waterlime in the cement quarry at Buffalo was filled with the characteristic gray sand of this formation, and at some localities where it is absent as a distinct stratum the basal tier of the succeeding limestone contains a considerable proportion of the same material.

At most exposures where the sand is not present this horizon is marked by a thin, uneven seam of black shaly matter, in which small pebbles of waterlime or black sand are imbedded forming a coarse conglomerate a few inches thick. The sandstone is absent and the horizon is but slightly marked on this quadrangle.

ONONDAGA LIMESTONE

This formation is composed of dark bluish gray limestone, bedded in layers from 3 inches to 2½ feet thick in which there is usually a quarter or less proportion of chert or hornstone in nodules or nodular layers. It was formerly known as the "Corniferous" limestone, and included in the "Upper Helderberg Group," a few layers at the base in which chert is absent being distinguished as the Onondaga limestone. The terms "Corniferous," and "Seneca" limestone were at one time used interchangeably. The term Onondaga limestone is now adopted to cover all the strata in central and western New York, which lie between the Oriskany horizon and the Marcellus black shale, here aggregating in thickness about 125 feet.

The limestone contains considerable black, carbonaceous matter that appears in the shaly partings and on the surface of the tiers. It is removed by slow decomposition on exposure and the rock weathers to a light bluish gray color.

The chert is usually very dark and but slightly translucent, but is sometimes much lighter colored and chalcedonic. It is very unevenly distributed in the beds predominating in some parts and frequently occurs in nodular layers that are continuous for long distances and the separate nodules from 1 to 3 inches in diameter occupy much of the remaining space.

Weathered outcrops and loose blocks from the cherty beds have a peculiarly ragged and scraggy appearance owing to the superior resistance to decomposition of the chert over the limestone. This chert, commonly called flint, was of the greatest value to our Indian predecessors as it is the material from which their spears, arrows and other implements were formed, but until recently its presence

has been regarded as seriously lessening the value of the limestone. Now, however, this rock is recognized as of great economic importance as constituting the best material, when crushed, for concrete work and road-building to be found in western New York and it is being extensively utilized for such purposes. At some outcrops one or more of the layers may be somewhat shaly, but all the remainder is compact and durable and is the source from which have been derived enormous quantities of dimension and building stone of the best quality as well as the purest quicklime.

At the base of the formation there occurs here 6 to 8 feet of limestone entirely free from chert. This condition is found at nearly all exposures of this horizon, the thickness in a few instances increasing to 25 or more feet. The rock is usually crowded with corals and crinoid stems, and is specially valued for ornamental building stone; it is also valuable as a flux in the manufacture of steel and is extensively quarried for such use. In the succeeding 40 or 50 feet the percentage of silicon is very high, reaching 50 per cent in some localities, while in some of the upper beds it is not more than 10 to 12 per cent.

This formation is rich in fossils. A list of the various species that occur in it may be seen in New York State Museum Bulletin 63, in which there are 3 of fishes, 39 of crustaceans, mostly trilobites, 13 of cephalopods, 3 pteropods, 38 gastropods, 15 lamellibranchs and 48 brachiopods. It also contains many species of corals and crinoids.

A few of the more common and distinguishing forms are:

Odontocephalus selenurus *Eaton*
Phacops cristata *var.* pipa *Hall and Clarke*
Gyroceras undulatum (*Vanuxem*)
Gyroceras trivolve (*Conrad*)

and the brachiopods

Atrypa reticularis *Linné*
Leptaena rhomboidalis *Wilckens*
Stropheodonta concava *Hall*
S. inequistriata (*Conrad*)
Spirifer acuminatus (*Conrad*)
Sp. divaricatus *Hall*

Exposures. The Onondaga limestone is covered by drift in most of the area in the northern part of the Attica quadrangle, where it is the surface rock. The largest outcrop is in the vicinity of an old quarry 2 miles north of Crittenden near the road to Murray where 12 to 15 feet of the upper layers are well displayed.

The lower beds are well exposed along the escarpment from the large quarry 2 miles northeast of Clarence to Williamsville and specially in both of those villages. The middle beds may be seen along Ellicott creek at Bowmansville and in some field outcrops and small quarries 2 miles north of Mill Grove, and the upper strata in the bed of Ellicott creek for a mile or two west of Mill Grove. At Bellevue what appear to be the uppermost layers of the Onondaga limestone are exposed in the bed of Cayuga creek north of the electric car line for 50 to 60 rods. The rock has been quarried here and the exposure includes about 10 feet. There is also a small outcrop of these strata in the south bank of the stream a mile northeast.

MARCELLUS BLACK SHALE

This term has been generally applied to a series of black and dark shales that immediately succeed the Onondaga and at the top pass gradually into the lighter colored Hamilton shales. At Marcellus, Onondaga county, from which locality the name is derived, only the lower beds are well exposed and recent observations in that region and in the western part of the State indicate the desirability of restricting the term to the lower shales exposed at the type locality.

Westward from Ontario county the Marcellus shale is clearly delimited on the top by the Stafford limestone, the shale above which, though very dark, is more calcareous and weathers to a light gray, while the rock between the Onondaga and the Stafford is a densely black and bituminous slaty shale with a few thin calcareous layers and, at some localities, a row of spherical concretions usually one to two feet in diameter.

On these quadrangles the Marcellus is 20 to 25 feet thick.

Fossils are common in the Marcellus shale at the base and for 3 or 4 feet at the top. Where this formation is more calcareous and lighter colored they are fairly abundant. A list numbering 20 species of those occurring in these beds at Lancaster may be found in New York State Museum Bulletin 49.

The following are the more abundant forms:

Ambocoelia nana *Grabau*
Chonetes mucronatus *Hall*
Isochilina? fabacea *Jones*
Liorhynchus limitare (*Vanuxem*)
Pterochaenia fragilis (*Hall*)
Nuculites triqueter *Conrad*
Orthoceras subulatum *Hall*
Strophalosia truncata (*Hall*)
Styliolina fissurella *Hall*

Exposures. A few inches of Marcellus black shale appear beneath the ledge of the Stafford limestone in the bed of Ellicott creek at Wende, south of the Lehigh Valley Railroad bridge. About 2 feet of black shale are exposed in Cayuga creek at Lancaster, just above the lower bridge, and also under the limestone below the Lake Como dam and similarly situated, in the bed of Plumb Bottom creek east of Foundry street. No other outcrops of the Marcellus shale occur on these quadrangles.

STAFFORD LIMESTONE

In western New York the Marcellus black shale is overlaid by a bluish gray compact limestone, that at its most eastern exposure on Flint creek in the town of Phelps, Ontario county, is but 4 inches thick but increases to 3 feet at Stafford, 8 feet 4 inches at Lancaster and, according to a well record, to 15 feet on Smoke creek in West Seneca. In the Seneca Lake valley this horizon is marked by a band of gray calcareous shale in which are imbedded spheric concretions containing fossils of the same species as those found in the limestone on these quadrangles. The largest exposure of this formation and the one most favorably situated for examination is in the beds of Cayuga and Plumb Bottom creeks in the village of Lancaster, where all the strata may be seen. It is here composed of 6 to 8 layers of limestone varying but slightly in lithologic character and quite fossiliferous throughout.

The Stafford limestone at Lancaster and its fauna have been fully described in New York State Museum Bulletin 49, with a complete list of the fossils and descriptions of species, of which there are 72. The more common forms are:

Ambocoelia nana *Grabau*
Chonetes mucronatus *Hall*
C. scitulus *Hall*
Liorhynchus limitare (*Vanuxem*)
Strophalosia truncata (*Hall*)
Meristella barrisi *Hall*
Spirifer subumbonatus *Hall*
Cypricardinia indenta *Conrad*
Orthoceras exile *Hall*
O. marcellense *Vanuxem*
Phacops rana *Green*
Primitiopsis punctulifera *Hall*

Exposures. Besides those mentioned as occurring at Lancaster, a small outcrop in the bed of Ellicott south of the Lehigh Valley Railroad bridge, and a very small one in an old pit 2 miles north of Alden, there is no exposure of Stafford limestone on these

quadrangles. There is a quite extensive field exposure at Stafford, from which village the name is taken, and the limestone appears in the cliff below Main street bridge in LeRoy, and also below the mill at Ashantee, near Avon.

CARDIFF SHALE

The upper beds usually included in the old term Marcellus and designated by Vanuxem the "Upper shales of Marcellus," are abundantly exposed near Cardiff, Onondaga county, and have been named from that locality (New York State Museum Bulletin 63, page 16).

The Cardiff shales decrease in thickness from the type locality westward to about 50 feet here, and also become much darker and more bituminous. On these quadrangles they vary but little in character from the shales below the Stafford limestone, though on the whole a little more calcareous and, after exposure, lighter colored. At the top there is a stratum of impure limestone 12 to 15 inches thick, quite hard but somewhat shaly in old exposures. The shales at the base and the limestone near the top of the formation are moderately fossiliferous, but the intervening beds are usually not rich in fossils.

The following forms have been reported from the calcareous lower shales overlying the Stafford limestone at Lancaster:

Ceratopora dichotoma *Grabau*
Chonetes lepidus *Hall*
Liorhynchus limitare (*Vanuxem*)
Atrypa reticularis *Linné*
Ambocoelia umbonata (*Conrad*)
Meristella barrisi *Hall*
Pterochaenia fragilis (*Hall*)
Styliolina fissurella *Hall*
Orthoceras aegea *Hall*
Phacops rana *Green*

Tornoceras uniangulare and Orbiculoidea minuta are common in these beds in Livingston and Ontario counties but are very rare here.

The only exposures of the Cardiff beds on these quadrangles are on Cayuga and Plumb Bottom creeks in Lancaster, where 2 or 3 feet of the lower shale succeeds the Stafford limestone, and at the junction of Cayuga and Little Buffalo creeks one-half mile east of Lancaster, where the hard layer mentioned (which here contains fine specimens of Phacops rana) is exposed under the highway bridge. The shale next above this hard layer for 10 to 12 feet belongs to this formation.

HAMILTON BEDS

SKANEATELES SHALE

The term "Skaneateles shale" was applied by Vanuxem to the beds overlying the Marcellus (Cardiff) shale and exposed on both sides of the north end of Skaneateles lake. It subsequently fell into disuse, but when the State Survey found itself compelled to adopt a more exact and refined classification of the strata than that hitherto in use, the term Skaneateles shale was re-applied in its original meaning and scope. It is the lowest division of the Hamilton beds, and on these quadrangles has an estimated thickness of 40 to 50 feet.

The passage from the Cardiff shale is a gradual one, there being but slight difference between the upper beds of that formation and the lower Skaneateles shales. They become lighter colored and more argillaceous in the upper part but the formation as a whole is much darker on these quadrangles than in the type locality.

The Skaneateles shale is delimited at the top by a calcareous band known as the Centerfield limestones. Fossils are common in the lower and more calcareous portion of the formation, but rare in the upper beds at most localities.

The following species have been reported as occurring in these beds on the Buffalo quadrangle:

Phacops rana *Green*
Cryphaeus boothi *Green*
Primitiopsis punctuliferus *Hall*
Orthoceras *sp.*
Tentaculites gracilistriatus *Hall*
Styliolina fissurella *Hall*
Euomphalus (Phanerotinus) laxus *Hall*
Bellerophon leda *Hall*
Pterochaenia fragilis (*Hall*)
Nuculites triqueter *Conrad*
Orthothetes arctostriatus *Hall*
Chonetes mucronatus *Hall*
C. setigerus (*Hall*)
C. scitulus *Hall*
C. lepidus *Hall*
Productella spinulicosta *Hall*
Strophalosia truncata (*Hall*)
Spirifer mucronatus *Conrad*
Ambocoelia umbonata (*Conrad*)
Liorhynchus limitare (*Vanuxem*)
Tropidoleptus carinatus (*Conrad*)
Crinoid stems.

Exposures. There are a few feet of Skaneateles shales uncovered below the limestones in the bed of Murder creek opposite the Losee schoolhouse one and one-fourth miles north of Darien, and also in the bed and banks of Crooked creek a mile west of the schoolhouse. The middle beds are exposed along Cayuga and Little Buffalo creeks 1 to 2 miles south and east of East Lancaster and also along Buffalo creek west of Blossom. The upper beds and the contact with the succeeding formation are displayed below the dam at Blossom.

LUDLOWVILLE SHALE

This formation embraces about 100 feet of soft, light colored shales in which there are interbedded many calcareous concretions and concretionary layers, and, near the base, a continuous band of thin limestones. It is capped by a stratum of encrinal limestone that is continuous from Madison county to Lake Erie.

The term Ludowville shale was adopted by Hall on account of the exposure of these beds at Ludlowville, on Cayuga lake. The calcareous band near the base was described in New York State Museum Bulletin 63 and designated the Centerfield limestone from its favorable exposure in the bed of Shaffer creek at Centerfield in Ontario county. It appears at all exposures of its horizon from that locality westward to Lake Erie varying but little in character except as to the relative thickness of the thin layers of hard limestone of which the band is composed. It is usually succeeded by a soft shale containing a great abundance of corals. At Centerfield and in the Delaware, Lackawanna & Western Railroad cuts 2 miles west of East Bethany, the exposures indicate coral reefs of considerable extent. This limestone resembles somewhat the Tichenor limestone that succeeds the Ludlowville shale and at isolated exposures has been mistaken for it. It is not represented in the coloring on the map but its position is shown by the north line of the Ludlowville area.

The beds in the middle part of the Ludlowville are not usually very fossiliferous, but the upper shales are richer and the concretionary layers contain many finely preserved specimens. The lower limestone at Centerfield afforded 92 species and Doctor Grabau's list of Ludlowville fossils from Eighteen Mile creek and vicinity names 120 species, embracing 6 crustaceans, 4 cephalopods, 4

pteropods, 29 lamellibranchs, 50 brachiopods, 1 crinoid, 8 bryozoans and 7 anthozoans. The common forms are:

Phacops rana *Green*
Cryphaeus boothi *Green*
Proetus rowi *Green*
Platyceras auriculatum *Hall*
P. thetis *Hall*
Nautilus magister *Hall*
Orthoceras nuntium *Hall*
Styliolina fissurella *Hall*
Diaphorostoma lineatum *Hall*
Pterinea flabellum *Conrad*
Actinopteria decussata *Hall*
Modiomorpha subalata *Conrad*
Palaeoneilo tenuistriata *Hall*
Stropheodonta demissa (*Conrad*)
Leptostrophia perplana (*Conrad*)
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Orthothetes arctostriatus *Hall*
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Sp. fimbriatus *Hall*
Sp. subumbona *Hall*
Ambocoelia umbonata (*Conrad*)
Athyris spiriferoides (*Eaton*)
Atrypa spinosa *Hall*
Camarotoechia dotis *Hall*
Tropidoleptus carinatus (*Conrad*)
Liorhynchus multicostum *Hall*
Pleurodictyum stylopora (*Eaton*)
Streptelasma rectum *Hall*

Exposures. There are many fine exposures of the Ludlowville shales on these quadrangles. The upper beds outcrop along Bowen brook and the entire section or nearly all of it along Murder creek north of Darien; along Ellicott creek one and three-fourths miles west of Darien Center, and along Spring creek and the Erie Railroad east of Alden. The middle beds are displayed in the bed of Cayuga creek a mile south and southeast from Marilla Station. At the fall in Buffalo creek at the Bullis bridge, 2 miles west of Marilla, the exposure of the upper beds and the contact with the Tichenor limestone is exceptionally large and favorable for the collection of fossils, and the middle and lower shales are displayed along the bed and banks of the stream to Elma and Blossom. The

upper beds with the overlying limestone are well exposed in the bed of Cazenovia creek below the bridge at Spring Brook.

TICHENOR LIMESTONE

The stratum of limestone that succeeds the Ludlowville shale has been commonly known as the "Encrinal limestone," a name applied to it by Hall in 1839 on account of the great abundance of fragments of crinoid stems contained in it.

Since this term has been applied by others to limestone layers of similar character occurring at distinctively different horizons and specially to the limestones in the lower Ludlowville beds, thereby causing confusion in the identification of horizons, a more distinctive appellation for this stratum was required. It has therefore been designated Tichenor limestone from its typical exposure in the ravine at Tichenor point on Canandaigua lake and along the shore toward the south. It usually consists of a single compact layer of bluish gray limestone, hard and durable, with a thickness varying from 12 to 18 inches and continuous, with many outcrops, from Onondaga county to Lake Erie, disappearing at the mouth of Pike creek.

This stratum in central New York is usually overlaid by calcareous shales, but on these quadrangles where the formation attains its greatest development on the line of outcrop it is followed by one or more layers of limestone that make the total thickness of the formation about 3 feet. The Tichenor limestone carries an abundant fauna. Doctor Grabau's list contains the names of 60 species occurring in it in this region, of which the following are the more abundant and striking forms:

Phacops rana *Green*
Diaphorostoma lineatum *Hall*
Modiomorpha concentrica *Conrad*
Rhipdomella vanuxemi *Hall*
R. penelope *Hall*
Spirifer granulosus (*Conrad*)
Sp. mucronatus *Hall*
Vitulina pustulosa *Hall*
Centronella impressa *Hall*
Cryptonella planirostra *Hall*
Tropidoleptus carinatus (*Conrad*)
Favosites hamiltoniae *Hall*

Exposures. The Tichenor limestone is exposed in the lower part of most of the principal ravines in the southern part of this quadrangle, and by reason of its superior resistance to the erosive power

of the stream, cascades have been produced with the limestone at the crests and long exposures in the banks farther down the stream. The larger and more accessible of these exposures are: on Bowen creek 2 miles northwest of Alexander; on Murder creek 30 rods below the bridge at Darien; on Ellicott creek one and three-fourths miles west of Darien Center; at west end of Erie Railroad cut 2 miles east of Alden; in the bed of Durkee creek at 900 A.T. and in the bed of a small stream flowing into Cayuga creek 2 miles south of West Alden. . At the Bullis bridge over Buffalo creek the Tichenor limestone is the crest of the fall, and is bare to the extent of half an acre above. It is displayed in the cliffs below the fall for one-quarter of a mile and the bed of the stream is strewn with large blocks from it. The Ludlowville and Moscow shales are also finely exposed, making this an exceedingly interesting as well as picturesque locality.

The limestone is well exposed in the bed of Cazenovia creek below the bridge at Spring Brook and also at the crest of a cascade in a small branch of Cazenovia creek, near the west line of the quadrangle 2 miles north of Webster Corners.

MOSCOW SHALE

This formation rests on the Tichenor limestone and consists in these quadrangles of about 50 feet of soft, light bluish gray shales that are usually somewhat calcareous and embrace several courses of flat concretions. The latter become at some exposures continuous concretionary layers crowded with fossils. Eastward from Ontario to Chenango counties the light colored Moscow is separated from the black Genesee shale by the Tully limestone, but west of Canandaigua lake and on these quadrangles this limestone and the Moscow beds are directly followed by thin lentils of iron pyrite or black shale.

Like most of the Devonic formations, the Moscow diminishes in thickness toward the west. At Moscow in the Genesee River valley, the locality from which the term Moscow shale is derived, the beds are 130 feet thick and on the south side of the mouth of Eighteen Mile creek at North Evans they measure but 17 feet.

Moscow shale is everywhere exceedingly rich in fossils, but the specimens are, as a rule, not so well preserved as in the Ludlowville shale, and there is little difference between the faunas of the Moscow and Ludlowville shale. Doctor Grabau reported 51 species from the Moscow beds in the Eighteen Mile creek region, the following being the more common forms:

Phacops rana *Green*
Tentaculites gracilistriatus *Hall*
Palaeoneilo tenuistriata *Hall*
Pholidops hamiltoniae *Hall*
Spirifer tullius *Hall*
Sp. consobrinus *d'Orbigny*
Chontes deflectus *Hall*
C. mucronatus *Hall*
Leptostrophia perplana (*Conrad*)
Ambocoelia umbonata (*Conrad*)
Atrypa reticularis *Linné*
A. spinosa *Hall*
Streptelasma rectum *Hall*
Cystiphyllum conifollis *Hall*

Exposures. The Moscow beds are advantageously exposed along Bowen brook 2 miles northwest of Alexander; along Murder creek between Griswold and Darien; in the bed of Ellicott creek from the fall one and three-fourths miles west of Darien Center to a low cascade 35 rods below the Erie Railroad bridge; in the Erie Railroad cut 2 miles east of Alden; in a ravine 2 miles southeast of West Alden; 6 feet of upper beds on Little Buffalo creek half a mile below Marilla; and especially fine and conveniently accesssible exposures are in the Buffalo Creek gorge above the falls at the Bullis bridge 2 miles west of Marilla; in the Cazenovia Creek gorge at Spring Brook and in a small ravine 2 miles north of Websters Corners.

TULLY HORIZON — PYRITE LENSES

The Tully limestone that succeeds the Moscow shale in central New York and is 30 feet thick in Onondaga county, thins out toward the west to Ontario county and is not known west of Canandaigua lake. In its place there appear at frequent intervals along the line of outcrop of this horizon, thin lenticular masses or lentils composed almost entirely of iron pyrites. These lentils in a few instances attain a thickness of 4 to 5 inches, but are usually less than 2, and they vary greatly in breadth, ranging from a few feet to the entire length of exposure many rods long.

Fossils are quite common in the pyrite and are mostly of species common in the Moscow or Genesee shales, but greatly reduced in size. A list prepared by Dr F. B. Loomis, published in New York State Museum Bulletin 69, contains the names of 48 species collected from the pyrite in this horizon in Ontario and Livingston counties. Most of these are pigmy forms of well-known species reduced to about one-fifteenth of their normal size. The more abundant forms are:

Spirifer mucronatus *mut.* hecate *Clarke*
" fimbriatus *mut.* pygmaeus *Loomis*
" granulosus *mut.* pluto *Clarke*
Ambocoelia umbonata *mut.* pygmaeus *Loomis*
Paracyclas lirata *mut.* pygmaeus *Loomis*
Tornoceras uniangulare *Conrad*
Orthoceras subulatum *mut.* pygmaea *Loomis*
Pleurotomaria, 3 species
Crinoid stems

Exposures. A thin lentil occurs in a small ravine half a mile west of Alexander and a similar one in the east bank of Murder creek 40 rods north of the railroad station at Griswold. A 1 inch lentil appears in the east bank of Ellicott creek one and one-half miles west of Darien Center, and at the iron bridge over Cayuga creek one and one-half miles below Cowlesville, a lentil of more than ordinary thickness and breadth is finely exposed. Another 2 inches thick, is in the banks of Little Buffalo creek half a mile below Marilla. There are traces of lentils in the long exposure of this horizon in the banks of Cazenovia creek south of Spring Brook, but they are all very thin.

GENESEE BLACK SHALE

The heavy beds of black and dark slaty shale that succeed the light colored Moscow shale in Ontario and Livingston counties were, in Hall's original classification, all included under the term Genesee shale, from their exposure in the Genesee river valley. Subsequent investigations disclosed such differences in the character of these beds as to require, in the interest of clearness and accuracy of description, a division into four distinct members or formations, the lowest of which in the type locality is 90 feet thick and capped by a bed of light gray limestone. The shale composing this member is nearly all densely black and slaty answering to the original description of the Genesee slate, and the use of that term is now restricted to these beds. It thins out from the type locality rapidly toward the west to about 20 feet on the east line of these quadrangles and to less than 2 feet on the western boundary.

Fossils are not usually abundant in the Genesee, but Chonetes setigera occurs in great numbers in the upper part at the exposure in Ellicott creek west of Darien Center and at the iron bridge north of Cowlesville. Styliolina fissurella is also common, and Pterochaenia fragilis and small cephalopods occur occasionally.

Exposures. This black shale is exposed in the ravine west of Alexander; above and below the railroad bridge at Griswold; below the railroad bridge a mile west of the station at Darien Center, and at a 5 foot fall in Durkee creek, 3 miles southeast from Alden, where the entire section with an interbedded row of spherical concretions and the overlying limestone are displayed. It is 8 feet 6 inches thick at the fine exposure under the Iron bridge northwest of Cowlesville; 7 feet in the bed of Buffalo creek below Marilla, 3 feet 6 inches in a long exposure in the gorge of Cazenovia creek south of Spring Brook.

GENUNDEWA LIMESTONE

From Canandaigua lake westward to Lake Erie the black Genesee shale is succeeded by a limestone formation consisting at Genundewa point on Canandaigua lake, of several thin layers of limestone and calcareous shale. The layers of limestone decrease in number toward the west, but as the remaining ones retain their peculiar characteristics the formation is easily recognized and is a convenient stratigraphic bench mark. On these quadrangles it consists of a concretionary layer 8 to 10 inches thick overlaid by 3 to 6 inches of limestone, slightly shaly and composed, in large proportion, of the minute shells of a pteropod, Styliolina fissurella. This characteristic is persistent, and the formation has been sometimes referred to as the "Styliola limestone" for this reason. Most of the exposures of the Genundewa limestone are in the bottom of ravines where, by its superior hardness over the shales beneath and above, small falls or cascades are produced. It is exposed in both branches of the ravine half a mile west of Alexander; in the bed of Murder creek on the south side of the Erie Railroad bridge at Griswold; in the bed of Ellicott creek 1 mile west of Darien Center; above the falls in Durkee creek southwest of Alden; under the iron bridge northwest of Cowlesville, and in a small ravine half a mile north of the bridge; finely in the bed of Buffalo creek at Marilla; in the banks of the Buffalo Creek gorge south of the Bullis bridge and in the Cazenovia Creek gorge south of Spring Brook. It dips beneath the water level of Lake Erie a mile southwest of Pike creek. The fauna of the Genundewa limestone in Ontario and Livingston counties comprised 44 species and is of peculiar interest in that the brachiopods and corals so abundant in the Ludlowville and Moscow calcareous layers and shales are absent here, and the fossils are mostly species of cepha-

lopods, gastropods and lamellibranchs that make their earliest appearance in this limestone.

The fauna includes the following species:

Manticoceras pattersoni *Hall*
Gephyroceras genundewa *Clarke*
Tornoceras uniangulare (*Conrad*)
Orthoceras atreus *Hall*
Styliolina fissurella *Hall*
Pleurotomaria genundewa *Clarke*
Bellerophon koeneni *Clarke*
Phragmostoma natator *Hall*
Loxonema noe *Clarke*
Pterochaenia fragilis (*Hall*)
Honeoyea styliophila *Clarke*
Ontaria suborbicularis *Hall*
Buchiolia retrostriata (*von Buch*)
Paracardium doris *Hall*
Melocrinus clarkei *Williams*
Plant remains and fish remains also occur.

WEST RIVER SHALE

The beds of dark shale that succeed the Genundewa limestone in the Genesee valley to the thickness of about 100 feet were until recently known as the upper Genesee shales. In that locality about 65 feet next above the limestone were dark bluish gray shales with thin layers of black shale interbedded at intervals of 3 to 8 feet. The term West River shale is now used to designate these beds on account of their abundant exposure in the West River valley in the western part of Yates county, the remaining 35 feet of the Upper Genesee beds receiving the name Middlesex black shale.

The thickness of the West River shale is decreased to 30 feet on the east line of these quadrangles and to 15 feet on the west boundary, but the character of the rock is not altered, spherical concretions and occasionally a thin calcareous sandstone flag appearing in the shales at nearly all exposures.

Fossils. The fauna of the West River shale embraces the following species, nearly all from the lighter colored shales:

Bactrites aciculum *Hall*
Gephyroceras *sp.*
Pleurotomaria rugulata *Hall*
Buchiola retrostriata (*von Buch*)
Panenka *sp.*
Pterochaenia fragilis *Hall*
Lunulicardium curtum *Hall*
Lingula spatulata *Vanuxem*
Orbiculoidea
Melocrinus clarkei *Williams*

Exposures. The West River shale outcrops in the banks of the ravines west of Alexander, and along Tannery creek at Attica to the little falls below the second highway bridge; at Griswold 25 rods south of the Erie Railroad in the west bank of Murder creek; along Ellicott creek below the railroad west of Darien Center; at the falls in Durkee creek southeast of Alden; in the west bank of Cayuga creek at the Iron bridge and in the small ravine half a mile north; also along Little Buffalo creek below Marilla; in the banks of the Buffalo Creek gorge one-half mile south of the Bullis bridge, and in the gorge of Cazenovia creek one and one-half miles south of Spring Brook.

MIDDLESEX BLACK SHALE

A band of black slaty shales about 20 feet in thickness succeeds the West River beds and is followed by argillaceous shales of a much lighter color. This band was formerly considered as a part of the upper Genesee shales, but differs from the beds below it not only in respect to its lithologic character, but also in its fauna, the characteristic fossils of the West River beds being absent from these.

In United States Geological Survey Bulletin 16, 1885, Clarke separated this black shale from the Genesee, and considered it under the term "Lower Blank Band of the Portage Group." In New York State Museum Bulletin 63 it received the designation Middlesex black shale on account of its abundant exposure in the Middlesex valley in Yates county, from which locality it is continuous westward without change of character, though diminishing gradually in thickness to about 6 feet at the point where it dips under the water of Lake Erie, in the town of Evans in Erie county. It is nearly barren of fossils except lignites. A small lingula, L. ligea, occurs in this horizon near the mouth of Pike creek.

Exposures. At the cascade on Tannery brook one-half mile northwest of Attica; on Murder creek 30 rods south of the railroad bridge at Griswold; near the Erie Railroad bridge over Ellicott creek; along Durkee creek; Little Buffalo creek at Marilla; Buffalo creek one mile below East Elma and along Cazenovia creek one and one-half miles south of Spring Brook.

CASHAQUA SHALE

This formation is composed of light bluish or olive clayey shales having an aggregate thickness on the east line of these quadrangles of about 80 feet, decreasing to 50 feet on the west line. Calcareous

concretions are common in the shale and blocky calcareous layers 2 to 5 inches thick occur at intervals of from 1 to 5 feet and a few thin flags also appear at some outcrops. The passage from dark to light shale at the bottom and from light to dark at the top is in both cases gradual through several alternations in 5 to 10 feet, but the formation presents an aspect so different from the beds above and below as to make recognition easy.

It was described and considered as the lowest member of the Portage group by Prof. James Hall in the Report on the Geology of the Fourth District, 1840, and by him designated the Cashaqua shale on account of its specially fine exposure along Cashaqua creek in Livingston county. The Cashaqua beds are 165 feet thick in the Genesee River gorge and but 32 feet in the cliffs on the shore of Lake Erie.

Fossils are not found in great abundance in these beds, but are fairly common in some of the upper shales, and some of the large flat concretions in the upper part of the formation contain finely preserved goniatites and orthoceratites.

The following are the more common and characteristic species of the Cashaqua shale:

Manticoceras pattersoni *Hall*
Probeloceras lutheri *Clarke*
Tornoceras uniangulare (*Conrad*)
Bactrites aciculum *Hall*
Orthoceras pacator *Hall*
O. ontario *Clarke*
O. filosum *Clarke*
Phragmostoma natator *Hall*
Lunulicardium (Pinnopsis) acutirostrum *Hall*
L. (Pinnopsis) ornatum *Hall*
Pterochaenia fragilis *Hall*
P. cashaqua *Clarke*
Honeoyea major *Clarke*
Ontaria suborbicularis *Hall*
O. accincta *Clarke*
Buchiola retrostriata (*von Buch*)
Paracardium doris *Hall*
Paleoneilo petila *Clarke*
Lingula ligea *Hall*
Aulopora annectens *Clarke*
Melocrinus clarkei *Williams*

Exposures. There are good exposures of the Cashaqua beds in both branches of Tannery brook a mile west of Attica. In the Murder Creek ravine at Griswold the entire section may be seen to excellent advantage. The upper beds are well shown below the

milldam at Cowlesville, and below the bridge over Buffalo creek at East Elma, and the entire section in the bed and sides of Cazenovia creek for more than a mile. There are also many outcrops in small ravines and roadside gutters.

RHINESTREET BLACK SHALE

This formation, consisting of a heavy mass of black shale succeeding the light colored Cashaqua beds, is 90 to 100 feet thick on the east line of these quadrangles and 150 feet on the west. With one exception, the Dunkirk black shale, higher in the series, it is the only Devonic formation that decreases in thickness toward the east. It extends as far as the Keuka Lake valley on the east, where outcrops show but 6 to 10 feet of the black shale, and to the shore of Lake Erie in the town of Evans, where it is 185 feet thick. On these quadrangles it includes a few thin bands of dark bluish gray shale usually from 3 to 5 feet thick that contain large symmetric concretions and septaria, some of which attain a diameter of 3 to 6 feet.

The black shales are quite barren of fossils, except plant remains, fish remains and conodont teeth, all of which are very rare. In the lighter shales obscure forms like those found in the Cashaqua shales occur but are also rare.

Exposures. Rhinestreet shale is the surface rock over a large area and is exposed in numerous ravines, frequently at and above cascades produced by its greater resistance to the erosive power of the streams than the more argillaceous Cashaqua shale. The larger exposures are along Tonawanda creek at Sierks; in the Tannery Brook ravines; in the upper part of Murder Creek ravine, along Cayuga creek at Folsomdale, Buffalo creek at Porterville and along Cazenovia creek at Jewettville and the banks of the gorge for 3 miles below.

HATCH SHALES AND FLAGS

In the Genesee River Gorge section the Rhinestreet shale is succeeded by about 150 feet of dark ferruginous and light blue shales with frequent layers of thin sandstone and overlaid by a well-defined sandstone. The black Rhinestreet shale and these beds were included by Professor Hall in the Report on the Geology of the Fourth District, 1842, in the formation designated "Gardeau flags and shales," but for reasons set forth in New York State Museum Bulletins 63 and 118 they were separated and considered as units in the Portage series and designated "Hatch flags and shales" from their exposure at the base of Hatch hill at the head of the

Canandaigua Lake valley. In Ontario and Livingston counties they are succeeded by a band of compact sandstone designated the Grimes sandstone.

The beds become softer toward the west and lighter colored, though black bands are frequent. Large flat concretions are common in the lower part and there are a few flags. Iron pyrite in nodules and small nodular masses is quite common in both shales and sandstones at some localities. Fossils are somewhat rare in this member of the series, but occur quite frequently in the lower beds and become more common toward the west.

The larger concretions mentioned contain very fine goniatites and other species along the Lake Erie shore. The fauna includes:

Manticoceras rhynchostoma *Clarke*
M. oxy *Clarke*
M. sororium *Clarke*
M. pattersoni *Hall*
Tornoceras uniangulare (*Conrad*)
Bactrites aciculum *Hall*
Ontaria suborbicularis *Hall*
Buchiola retrostriata (*von Buch*)
Paracardium doris *Hall*
Pterochaenia fragilis (*Hall*)
Cladochonus *sp.*
Lignites and fucoids also occur.

Exposures. Along Crow creek above the reservoir 2½ miles southeast of Attica; in Tannery brook below Danley Corners; in the ravine of the Right branch of Cayuga creek below Bennington, and along Hunters creek a mile southwest of Wales Center, and along the road leading west from Jewettville.

GARDEAU FLAGS AND SHALES

As set forth in New York State Museum Bulletin 118, this term is now used to designate the strata resting upon the Grimes sandstone in Livingston and Ontario counties and succeeded by the Nunda sandstones. The Grimes sandstones thin out westwardly and have not been traced to these quadrangles with certainty, but an arenaceous band consisting of two or three sandstones 12 to 18 inches thick that appears to be at or near the Grimes horizon marks a change in the sedimentation and is here considered the base of the Gardeau beds.

This formation is composed of sandstones, thin flags, hard sandy shales, soft clayey shales and in the lower part a considerable proportion of dark to black shale that increases toward the west and large calcareous concretions occur in all parts. A bed of black

shale near the base, much heavier on the shore of Lake Erie, has been designated the "Dunkirk black shale." The aggregate thickness of the Gardeau beds on these quadrangles is approximately 300 feet.

Fossils are very rare in most of the strata, except some of the light colored soft shales, where they are fairly common. The fauna is composed of the following species:

Manticoceras rhynchostoma *Clarke*
M. pattersoni *Hall*
M. oxy *Clarke*
Tornoceras uniangulare *Conrad*
Orthoceras pacator *Hall*
Bactrites aciculum *Hall*
Styliolina fissurella *Hall*
Phragmostoma natator *Hall*
Loxonema multiplicatum *Clarke*
Palaeotrochus praecursor *Clarke*
Lunulicardium bickense *Holzapfel*
Honeoyea erinacea *Clarke*
H. major *Clarke*
H. desmata *Clarke*
Posidonia attica *Williams*
Ontaria suborbicularis *Hall*
O. clarkei (*Beushausen*)
Euthydesma subtextile *Hall*
Buchiola retrostriata *von Buch*
B. lupina *Clarke*
Paracardium doris *Hall*
Pterochaenia fragilis *Hall*
Hydnoceras nodosum *Hall*
Cladochonus *sp.*
Lignites.

Exposures. Exposures of the Gardeau flags and shales are in all the ravines on the west side of the Tonawanda Creek valley, and specially good ones are in the large ravine above the railroad west of Varysburg, and in the large Stony Brook ravine east of that village. The flags and heavier sandstones crop out in many of the small gullies in the towns of Bennington and Sheldon and those in the southern part of Attica.

NUNDA SANDSTONES

Toward the west from the Genesee River gorge at Portageville where this formation is a nearly homogeneous mass of compact light bluish gray sandstone nearly 200 feet thick, it gradually becomes softer and more shaly. This tendency appears to be stronger in the lower portion, reducing the thickness of the strata retaining

the characteristics of the sandstones at the type locality to 125 to 150 feet on these quadrangles and of these some are less compact.

Fossils (except lignites) are rarely found in the sandstones and there are very few in the shaly partings. The following forms, collected at Portageville, constitute the fauna of the Nunda sandstones in this region:

Manticoceras oxy *Clarke*
M. rhynchostoma *Clarke*
Orbiculoidea *sp.*
Cladochonus *sp.*
Crinoid stems
Fucoids

Exposures. The Nunda beds are well exposed in but two localities on these quadrangles. The entire section may be seen in the bed and sides of the upper part of a ravine in the hillside west of Varysburg, and at the highway bridge over the Stony Brook gorge 2 miles east of Varysburg. There are small outcrops near South Attica, also on Poland hill and west of Persons Corners.

WISCOY SHALES

This formation, named from its exposure at the falls of West Coy creek at Wiscoy in the Genesee River valley, is composed at the type locality of a band of black shale 20 feet thick at the base, succeeded by 150 to 170 feet of light soft shale resembling the Cashaqua beds, with thin bands of black shale and a few thin layers of hard and soft sandstones. Calcareous concretions are common at some horizons.

The formation is capped by a band of hard, calcareous sandstones, containing brachiopods, that produces in the bed of the Genesee river a small cascade known as Long Beards riffs. These beds were formerly considered as belonging to the Chemung group, but their close resemblance lithologically and in the character of their fossils, to the Cashaqua beds, and the entire absence of the brachiopods that distinguish the Chemung rocks, have been deemed sufficient grounds for their description as a separate formation.

Fossils. The following species occur at Wiscoy:

Manticoceras oxy *Clarke*
Orthoceras *sp.*
Pleurotomaria *sp.*
Hyolithes neapolis *Clarke*
Buchiola retrostriata (*von Buch*)

Lunulicardium (Pinnopsis) wiscoyense *Clarke*
Paracardium doris *Hall*
Lingula ligea *Hall*
Zaphrentis *sp.*

Exposures. The basal black band, 15 feet thick, is exposed in the upper part of the ravine west of Varysburg with a few feet of the lighter nodular shales above.

CHEMUNG SANDSTONE AND SHALES

Sandstones and shales of this division are the surface rocks over a small area on the hill west of Varysburg, but are not exposed on these quadrangles.

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LEGEND

SILURIC
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- Cardiff shale
- Skaneateles shale
- Ludlowville shale
- Tichenor limestone
- Moscow shale
- Pyrite in Tully horizon
- Genesee black shale
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- West River shale
- Middlesex black shale
- Cashaqua shale
- Rhinestreet black shale
- Hatch shales and flags
- Gardeau flags and shales
- Nunda sandstone
- Wiscoy shale
- Chemung

SILURIC
DEVONIC
Erian
Stockton

Scale 1/250000
Miles
Kilometers
Contour interval 20 feet.
Datum is mean sea level.

Field work by D. D. Luther
1903

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